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EMITTER SURFACE TEMPERATURE DISTRIBUTION FOR A MINIATURE THERMIONIC DIODE

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16. Abstract

Brightness temperatures have been observed from five hohlraums equally spaced on a diameter of a 0.635-cm thermionic emitter surface. The hohlraums are 0.0381 cm in diameter and are 0.114 cm deep. The surface was mounted in a simulated diminiode geometry and was heated from the backside, according to the design, by electron bombardment. Several temperature observations were made at each hohlraum at four different levels of input power. Within experimental error no measurable temperature gradients across the emitter surface were observed at any input power level.

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SUMMARY

Brightness temperatures of five equally spaced hohlraums located on a diameter emitter surface of a miniature thermionic diode (diminiode) have been observed. The hohlraums have an l/d of three with diameters of 0.0381 centimeter. The surface was heated according to the diminiode design from its backside by electron bombardment to four different operating temperatures. Within experimental error no measurable gradient in the emitter surface temperature was observed at any of these operating temperatures.

INTRODUCTION

Better performing electrodes have become a necessity with the advancement of nuclear thermionics. To satisfy this need, a program to screen promising emitters and collectors and to provide detailed performance maps has been initiated. This program uses a test vehicle called a diminiode which is described in reference 1. Relatively small, 0.635 centimeter diameters, emitters are the core of this miniature thermionic diode. Since the thermionic performance of these emitters is of prime importance, knowledge of the surface temperature distribution is necessary. This report describes the experimental results obtained by probing the emitter surface of a mock diminiode for its temperature distribution.

MOCK DIMINIODE

A four-times scale sketch of the mock diminiode used in the present experiment is shown on figure 1. It is identical to a prototypic diminiode with the exception of the

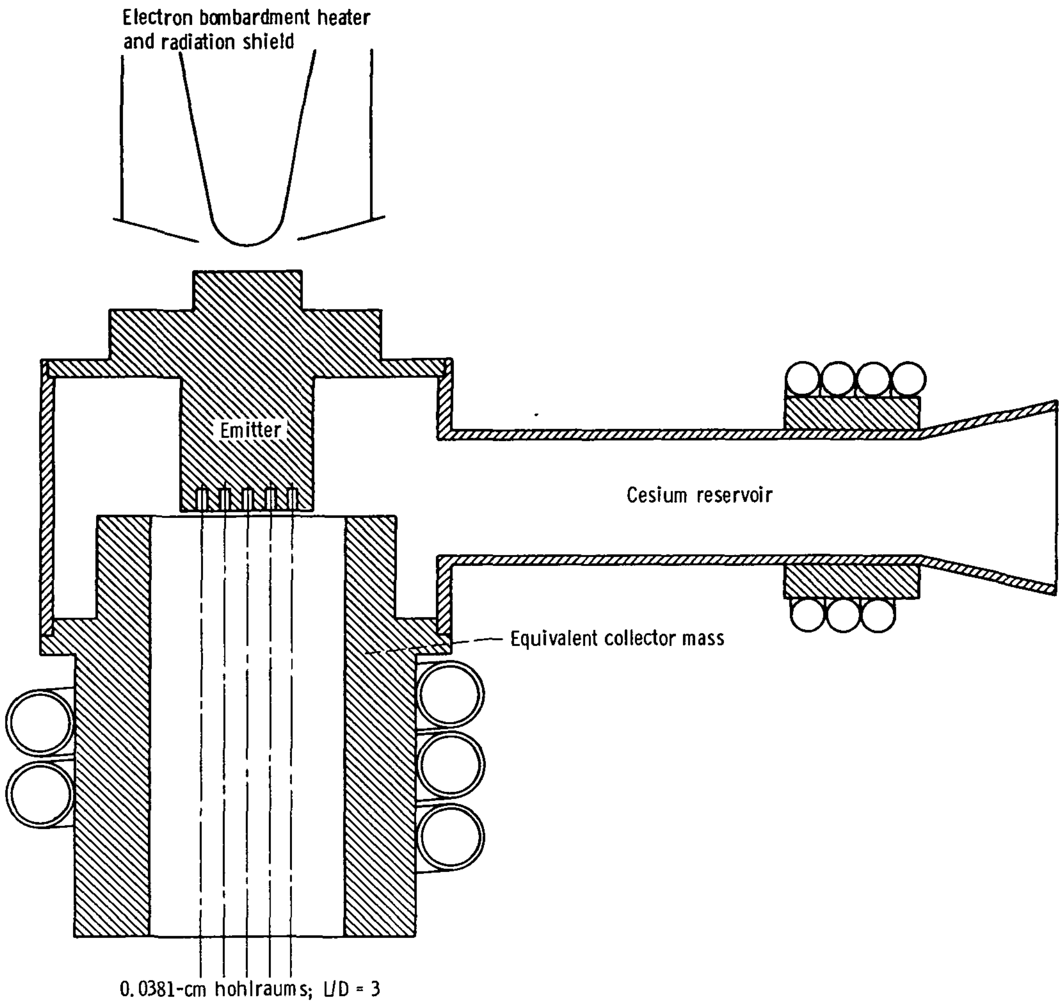


Figure 1. - Mock diminiode.

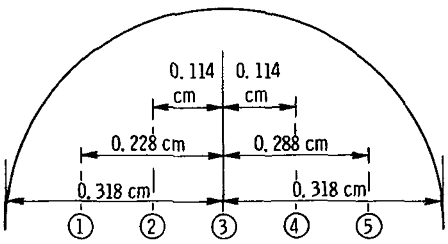
collector and cermet configuration (ref. 1), which has been replaced with an equivalent mass bored out to expose the surface of the emitter. Tantalum is used exclusively in the mock diminiode, whereas in the prototype diode the collector and cermet base material is niobium, 1-percent-zirconium alloy. The emitter and collector materials used in prototype diminiodes, of course, can be any promising material. In the prototype diminiode the emitter (nominally 0.318 cm thick) is diffusion bonded to a tantalum substrate similar in design to the emitter structure used in the present experiment.

On the active face of the mock emitter are five blackbody cavities which have been bored, equally spaced, on a diameter of the emitter. These hohlraums are 0.0381 centimeter in diameter and 0.114 centimeter deep. The length to diameter ratio of these holes is three; and although a cavity having this ratio has an effective cavity emittance of less than one, the holes are uniformly bored and do yield representative surface temperatures.

The backside of the emitter is heated by electron bombardment using a hairpin filament to simulate actual diminiode operations. An electrically floating radiation shield is used to confine and direct the bombardment current and thermal radiation into the emitter.

TEST PROCEDURE AND RESULTS

The electron bombardment power was adjusted to four different levels between 100 and 278 watts. These power levels produced emitter surface temperatures between 1450 and 2000 K, which are the normal operating temperatures of the diminiode. At each level of input power, three temperature observations were recorded from every hohlraum using an optical pyrometer calibrated against an NBS tungsten strip lamp. These temperature measurements were made by three individual observers, with each individual making several line-reversal observations on every hohlraum to reduce the possibility of human error. The actual temperature measurements recorded by the observers are shown on figure 2. Also shown in the figure are the locations of the hohl-



Input power, W	Temperature, K				
	T_1	T_2	T_3	T_4	T_5
100	1454 1455 1458	1458 1454 1453	1457 1456 1455	1459 1456 1454	1459 1459 1457
160	1628 1634 1630	1628 1629 1628	1626 1631 1627	1627 1631 1628	1627 1631 1627
220	1819 1824 1822	1817 1824 1820	1814 1822 1822	1818 1822 1822	1816 1824 1823
278	1979 1974 1976	1982 1975 1976	1979 1974 1976	1982 1976 1982	1978 1974 1977

Note: Observed temperatures are uncorrected for emittance of 0.0381-centimeter-diameter hohlraums (L/D = 3). Indicated temperatures are those of several observations at each hohlraum

Figure 2. - Emitter surface temperature distribution at various levels of input power.

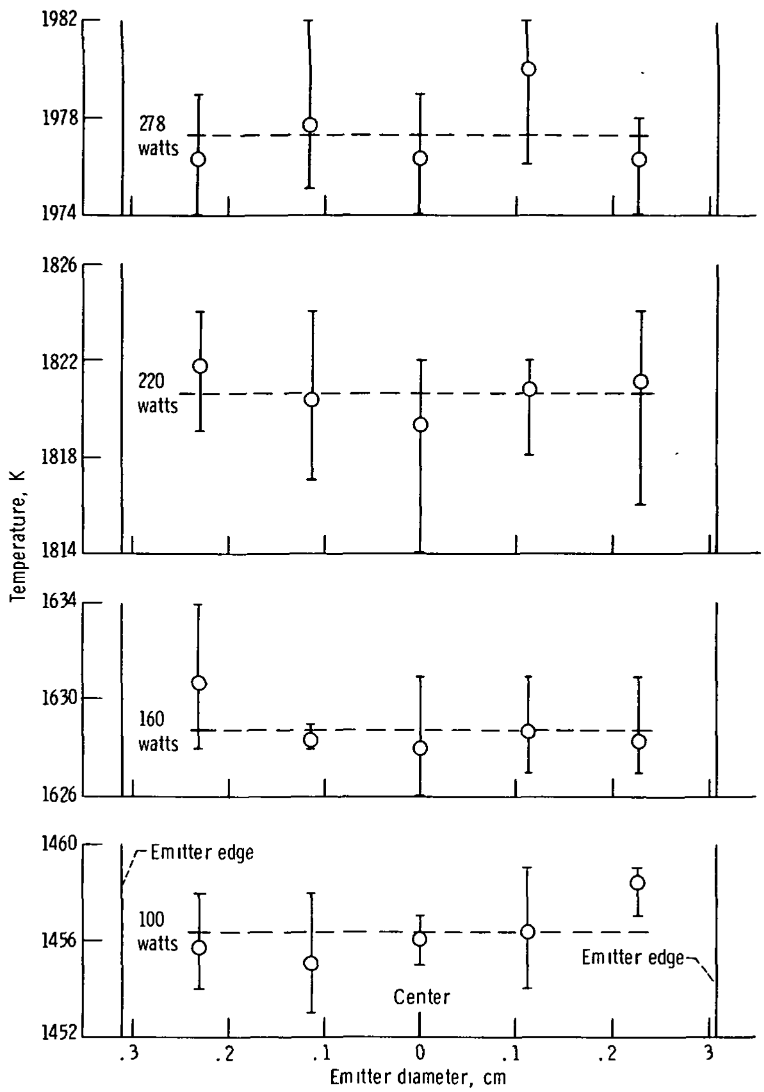


Figure 3 - Average observed hohlraum temperatures at various input powers Error bars indicate range of experimental observations. Dashed lines indicate average of all observations.

raums relative to the edge of the emitter. The variation in the observed temperatures from hohlraum 1 to hohlraum 5 was 6 to 10 K; and for any one of the observers it was 2 to 6 K. Figure 3 shows the distribution of the average observed temperature across the emitter surface at four different temperature levels. Within experimental error no definite temperature gradients across the emitter surface were observed at any input power level.

Although the temperatures of the edge of the emitter were not observed, the area over which the uniform temperature was documented was larger than the area of a prototypic collector without its guard ring.

Of course, the conditions for this evaluation did not exactly duplicate those of actual diminiode operations. But these results tend to verify the achievement of a major design requirement: uniform electrode surface temperature distributions.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, May 24, 1972,
112-27.

REFERENCE

1. Morris, James F.: The Diminiode: A Research and Development Tool for Nuclear Thermionics. NASA TM X-2586, 1972.

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